CHARCOAL VACUA*

(*From a Correspondent.*)

PROF. DEWAR began his discourse by describing the different processes which have been adopted for obtaining very perfect vacua, and referred to a paper regarding this matter, read by Prof. Tait and himself before the Society last year.

By the ordinary air-pump the exhaustion can only be obtained to $\frac{1}{8}$ of an inch, *i.e.* $\frac{1}{240}$ of the ordinary pressure.

Regnault, in some of his experiments, after exhausting with the air-pump, boiled water, and when the water had evaporated, sealed the vessel, and then broke a flask inside containing sulphuric acid, and so the water vapour was absorbed.

Dr. Andrews' way is a revival of one due to Davy, viz. to fill and exhaust twice with carbonic acid after the pump exhaustion, and then by caustic potash to fix the CO_2 which is left.

Professors Tait and Dewar's method is to take advantage of the power charcoal has of condensing gases; while the exhaustion, by means of a mercury pump, is going on, the charcoal is kept heated; when the exhaustion has been carried as far as possible, the vessel is sealed, and as the charcoal cools, it condenses the very small residue of gas there may be present, and this can again be temporarily driven out by heating the charcoal. The test they have employed to gauge the perfection of their vacuum has been to see if it will allow an electric spark to pass. It is well known that at the ordinary atmospheric density it requires considerable tension for a spark to pass through air, and as the density diminishes, the spark passes more easily; but when a certain point is reached the difficulty again increases, and in a very perfect vacuum no spark passes at all. Two wires, $\frac{1}{4}$ inch apart, in one of Tait and Dewar's exhausted tubes would not allow a spark to pass, although a powerful coil was employed.

Prof. Dewar went on to say that the effect of light and heat had been tried by many experimenters, on magnets and delicately suspended bodies, and in the *Edinburgh New Philosophical Journal* for 1828 there is an interesting account of some experiments performed by Mark Watt on the same subject, with apparatus little differing in appearance from that now used by Mr. Crookes.

Recently Mr. Crookes has found some curious results which he seems to think are inexplicable. He found that the action of a beam of light on a delicately suspended glass fibre with a disc at each end was repulsion of the disc when the exhaustion was perfect, but attraction when at ordinary pressures. The discs were light bodies of pith or cork. One side of each was covered with lampblack, the other was white. The first thing to be noticed is that the blackened face is affected much sooner than the white face. Since there was attraction at one density and repulsion at another, it follows that at some intermediate density there is no action at all, and this neutral point depends among other things on the conductivity of the body and the nature of the residual gas.

It will be seen that for delicate action one essential is that the glass of the vessel be thin. The sensibility is also found to increase with the perfection of the vacuum.

The first fact ascertained is that the action follows the law of the inverse square of the distance, that which all radiation obeys. Thus, when the light was $3\frac{3}{4}$ inches from the beam, the reading was 110, zero 22, deflection 88; at $7\frac{1}{2}$, reading 48, deflection 22, or only about $\frac{1}{4}$; and when at $11\frac{1}{2}$, reading 33; and as zero changed, reading 33, deflection 9, or only about $\frac{1}{9}$.

The next experiment was this. Professor Dewar interposed between the candle and the beam a substance opaque to heat rays. The candle was placed so as to give a large deflection, and then a vessel of ordinary glass was interposed, and the deflection decreased, and on filling the vessel with water, which is almost opaque to heat rays, there was no perceptible deflection left. This shows that when the heat rays are absorbed or prevented from reaching the disc, hardly any action takes place. A layer of water $\frac{1}{4}$ of an inch thick diminishes the amount of deflection to $\frac{1}{8}$ part of the original.

Next a smoked piece of rock-salt was interposed, or a vessel filled with a substance transparent to heat but opaque to light, viz., a solution of iodine in bisulphide of carbon. The deflection was as before, large; on the empty screen being interposed a diminution followed, due to the non-transparency of the glass screen for heat. But when by means of the iodine solution the light rays were cut off there was hardly any further diminution in the deflection. This shows that the light rays may be taken away without any considerable diminution of the action.

Prof. Dewar then proceeded to show that the heating of the disc was the efficient cause of the action.

Two equal discs, one of rock-salt, the other of glass, were attached to the glass fibre. The rock-salt was inactive when the beam was thrown on it; the glass disc was active. The reason is evidently that the rock-salt is not heated, being transparent to heat, whereas the glass is opaque, absorbs the heat and is heated. Unless the shell of the receiver be thin, however, the selective action is very small, as the glass envelope absorbs much of the heat.

The back of the rock-salt disc was then coated with lampblack, and the beam sent through to the blackened side. Yet there would be attraction. The heat and light passes through the rock-salt and is absorbed by the lampblack at the surface of contact. The lampblack is heated up in consequence, but it is so bad a conductor that before this heat can be conducted through the thin coating of lampblack it is conducted through the rock-salt, heats it up, and the action is repulsion. If the lampblack were not so bad a conductor, all the lampblack would be first heated up and there would be repulsion at the other side, or apparent attraction. The subsequent action is due to the giving out heat unequally on the two sides.

The next modification was to substitute for the rock-salt clear sulphur and ordinary sulphur on the other. The peculiarity of clear sulphur is that when acted on by light it resumes the appearance of ordinary sulphur, with a disengagement of heat. A beam was thrown on this, and the effect was, as expected, attraction, the back being heated, and repulsion, there being attraction on the other side. The success of this experiment depends on the way in which the sulphur is transforming.

This suggested to the learned Professors an instrument for detecting the presence of very high violet rays. Have the transparent discs coated with white phosphorus, which is opaque to the ultra-violet rays. There would ensue a chemical action with disengagement of heat, and the result would be a motion of the discs. To show the sensitiveness of the apparatus, it may be stated that an ordinary lucifer-match held at a distance of 4 feet produced instant action, which was observed by means of a telescope. When ether was brought near there was attraction. The disc followed the ether about because there was radiation of heat from the disc. The action is clearly due to the infinitesimal heating of the discs. Reynolds suggested the action was due to the evaporation of some fluid on the surface of the discs. The recoil of the evaporating particles leaving the disc sent it back.

When the action takes place in ordinary pressures it is probably due to convection currents. The air in front of the disc is heated and ascends, there is a vacuum, and hence the disc advances. To understand the action that takes place when the exhaustion is more perfect, we must consider how much gas there is in the vessel. The capacity

* By Professors Tait and Dewar. Paper read by Prof. Dewar before the R.S. of Edinburgh on Monday, July 12.

of the vessel is about a litre or 1000 cubic centimetres. But since we know that the exhaustion has reduced the density to $\frac{1}{4000000}$ of its original, the volume occupied by the residual gas at ordinary pressures would be that of a little bubble $\frac{1}{100}$ of an inch in diameter.

Sir Wm. Thomson, T. Clerk-Maxwell, and Clausius have shown that in a gas, at ordinary pressure, the mean or average path between two collisions is about $\frac{1}{10000}$ of a millimetre. When the pressure is reduced to $\frac{1}{4000000}$ the mean will be 400 millimetres, or about a foot and a half. What takes place is this. The particles of the gas are flying about in all directions, with a velocity which depends on the temperature. When they impinge on the heated disc their velocity is increased, they go off with a greater velocity than those which go off from the colder side, and hence there is a recoil of the disc. When the gas is at all dense the particles get a very short way before they are met by another and sent back, and so the velocity gets a common velocity before any visible action takes place. When the gas is rare the particles may get a long way off before they meet others, and so the action becomes perceptible.

In case of cooling they go away with diminished velocity and a negative recoil.

The author of the paper went on to show that the total mechanical action on a square centimetre of black surface derived from the radiation of a magnesium lamp, at a distance of 150 mill., did not exceed a continuous pressure of $\frac{1}{50}$ part of a milligramme, and that the total work done did not amount to the five-millionth part of the available energy received by the movable surfaces.

*ADDITION TO OUR KNOWLEDGE OF THE TERMITES**

FRITZ MÜLLER has recently published a short but interesting memoir on the larvæ of Calotermes, a genus of Termites, which he describes with his wonted care and accuracy. We cannot, of course, here follow him in detail; but, as is so often the case in the writings of this eminent naturalist, he draws our attention by his descriptions to several points of unusual interest. As occurs in some other insects, the youngest larvæ of Calotermes differ much in form from those somewhat more advanced in age. The form of the younger larvæ may be accounted for on two hypotheses. It may be an adaptation to the mode of life, or it may be the original larval form of the group. In the latter case, Herr Müller considers that it would be an extremely interesting form, because, in his opinion, Calotermes is one of the oldest, if not the oldest, of existing insect genera; since, according to Hagen, the carboniferous Termites described by Goldenburg from the cold strata belong to this group. Under the latter hypothesis, therefore, the younger larvæ of Calotermes would have, as regards insects, an interest similar to that possessed by Nauplius among Crustacea; and, according to Müller, the latter really is the case. The youngest larvæ of Calotermes live with their elder sisters, in the same localities, on the same food, and, in fact, under precisely the same conditions. These older larvæ have, in a word, completely adapted themselves to their dwelling-place and mode of life. Like most animals which burrow in earth, wood, or stone, they are cylindrical in form. Not so the youngest larvæ, which are flattened, and have the thorax laterally expanded. Their structure is, in Müller's opinion, as unsuitable as possible for animals inhabiting wood. This form is therefore probably only possessed through inheritance from far distant ancestors.

It is unnecessary to point out how great is the interest attaching to these larvæ, if Müller's view be correct; nor would I venture to express any dissent from his conclusions. But, I confess, there seems to me a difficulty in comprehending why the younger larvæ have not adapted themselves to their conditions, in like manner as their elders.

* By Fritz Müller.

May there not possibly be some circumstances which have hitherto escaped observation, and which might render the form of these larvæ not so altogether unsuitable as Müller supposes?

I will just refer to one other point in this interesting paper. The author shows that the main, if not the whole growth of the antenna takes place in the third segment: the two basal ones and the terminal portion remaining almost unaltered. My husband, many years ago (Linn. Trans., 1863), showed this to be the case in the Ephemera (*Chloeön*), and it would be interesting to know whether the same thing occurs among other Neuroptera.

High Elms ELLEN LUBBOCK

NOTES

THE Loan Exhibition of Scientific Apparatus at South Kensington, to which we have already referred (vol. xi. p. 301), will open on the 1st of April, 1876, and remain open until the end of September, after which time the objects will be returned to the owners. It will, as we have already intimated, consist of instruments and apparatus employed for research, and other scientific purposes, and for teaching. It will also include apparatus illustrative of the progress of science, and its application to the arts, as well as such as may possess special interest on account of the persons by whom, or the investigations in which, it had been employed. The precise limits are detailed under several sections in a syllabus which has been issued for the information of exhibitors. Models, drawings, or photographs will also be admissible where the originals cannot be sent. The apparatus may, in certain cases, be arranged in train as used for typical investigations; and arrangements will be made, as far as it may be found practicable, for systematically explaining and illustrating the use of the apparatus in the various sections. Forms on which to enter descriptions of objects offered for exhibition may be obtained on application to the Director of the South Kensington Museum, London, S.W. These forms should be filled up and returned as soon as possible, so that exhibitors may receive early intimation as to the admissibility of the objects they propose to send. The cost of carriage of all objects selected for exhibition will be defrayed by the Science and Art Department. It is hoped that institutions or individuals having instruments of historic interest will be good enough to lend them. The following are the various sections into which the Exhibition will be divided:—Arithmetic, Geometry, Measurement, Kinematics, Statics and Dynamics, Molecular Physics, Sound, Light, Heat, Magnetism, Electricity, Astronomy, Applied Mechanics—[as the Exhibition must be regarded as chiefly referring to education, research, and other scientific purposes, it must in this division consist principally of models, diagrams, mechanical drawings, and small machines, illustrative of the principles and progress of mechanical science, and of the application of mechanics to the arts],—Chemistry Meteorology, Geography, Geology and Mining, Mineralogy, Crystallography, and Biology.

MR. SULLIVAN on Tuesday, in the House of Commons, moved with regard to the necessity for having a Museum of Science and Art in Dublin. He, as well as the other speakers, seems to be ignorant of the fact that in addition to its educational staff and appliances, the Royal College of Science in Dublin possesses the germ of an admirable museum which formerly constituted the Museum of Irish Industry. It seems probable that what is needed is a removal of the specimens from the College to a suitable building; probably an enlargement of the Royal Dublin Society would be best, and the space thus gained in the College of cience